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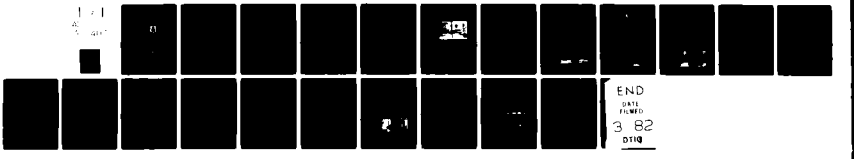

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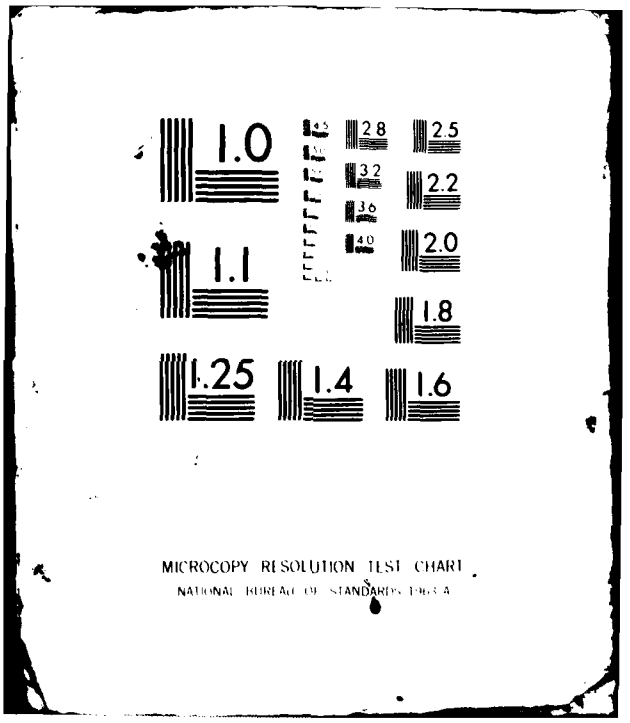
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FOREIGN TECHNOLOGY DIVISION

EXPEDITIONARY WORKS ON THE STUDY OF THE CLOUDS OF THE CRIMEAN COAST OF THE BLACK SEA

by

A.F. Dyubyuk

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EDITED TRANSLATION

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By: A.F. Dyubyuk

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteratio..
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
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Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sh	arc sh	$\sinh^{-1}$
cos	cos	ch	ch	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

Expeditionary Works on the Study of the Clouds of the Crimean Coast of the Black Sea

A. F. Dyubyuk

In the summers of 1954 and 1956 under the direction of Prof. A. Kh. Khrgian works were carried out on the study of the breezes of the southern coast of the Crimea. Being a member of the 1956 expedition for a short time, the author became interested in the nature of the effect of local factors on cloud development, in connection with which in 1957 and 1958 under his supervision special expeditions were organized on the study of clouds in this region.

The works were carried out by the department of atmospheric physics of the Physics Department of MGU (Moscow State University).

The expedition was located on the Katsiveli Peninsula near Simeiz, being based at the Black Sea Department of the Maritime Hydrophysical Institute of the Academy of Sciences of the USSR. Thus, the base of the expeditionary group of atmospheric physics was located almost at the very southern tip of the Crimean Peninsula.

In 1957 the works were carried out during August, and in 1958 - from the end of June to the end of August. Parallel with the regular meteorological and the more limited radio-sounding observations, the employment of photographic methods were broadly organized in the ex-

peditions of 1957 and 1958.

At first, the recording of the cloud shapes and their location over the mountains was carried out by photographing by hand with roll-film cameras of the FED (F. E. Dzerzhinskiy) type,("Kiev," "Ekzakta," and "Zorkiy."). Panoramic (above the mountains or the sea) photographing and repetitive photographing of one and the same cloud forms were carried out; the first gave the pattern of the location of the clouds, and the second gave their development in time. Photographing through a spherical mirror was employed for these purposes; this photographing was created by T. N. Bibibkovaya.

Second, base-line, photogrammetric photographing was carried out to determine the spatial coordinates of the clouds, their horizontal movements and the speeds of vertical development. In 1957 M. V. Kartashova paved the way for this type of photography with the aid of pilot balloon theodolites, on which FED-type cameras were placed. In 1958, moreover, an experiment employing TAL phototheodolites of the Aerial Photographic Methods Laboratory of MGU (Moscow State University) was conducted, which was supervised by N. A. Raspolozhenskiy, and N. N. Kondrat'yev carried out the subsequent proce-sing. In 1958 an experiment involving normal and time-lapse (stop-motion) photographing of the development of clouds with a KS-50B movie camera was carried out.

Photogrammetric photographing was conducted with a base line of the order of 1,000 m. The complete processing of the wealth of material obtained by the expedition still has not been completed and, since this wor- to a considerable degree has a methodical nature, let us examine in the article only a number of individual examples.

Examples of the Panoramic and Repetitive Photographing of Clouds by Hand (without a tripod)

1. Cumulus Clouds of Breeze Circulation

During breeze circulation, frequently encountered on the southern

coast of the Crimea, during the day, below the level of the mountains there is distinguished a wind with a component, directed from the sea, whereas above the mountains and at approximately this same level above the coast a wind (very close to geostrophic) is directed towards the sea.

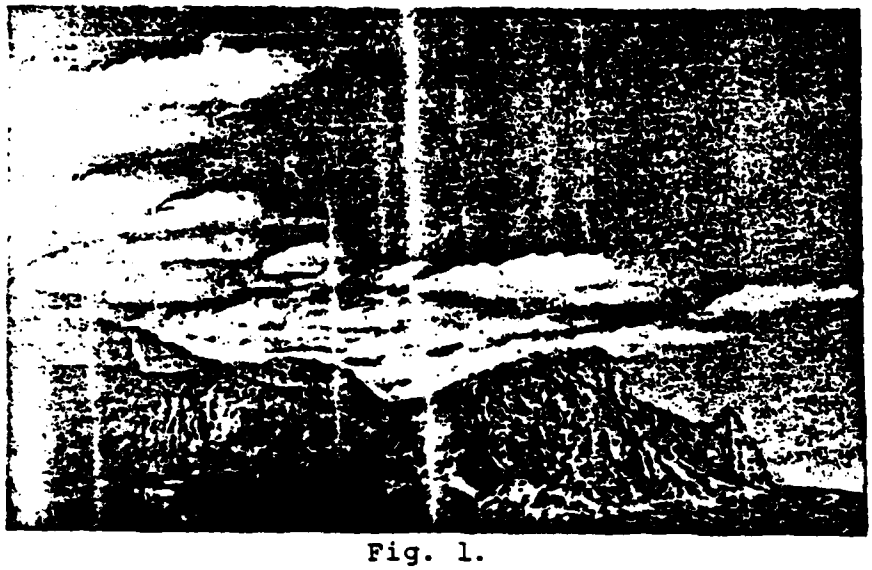

Fig. 1.

Cumulus clouds, developed above the mountains (Yayla), are moved by the upper air current towards the sea and in a descending flow gradually melt away. One of the many examples of such a process can be the clouds, which were observed on 10 August 1957. This process (Fig. 1) is very evident on the photographic panorama, which encompasses the mountains.

The magnitude of the movement of the Cu from the mountains towards the se- and their vertical development is established depending on the speed of the upper air current and the conditions of the distribution of temperature and atmospheric humidity.

2. The Development of Thick Cumulus Clouds above Protruding Mountain Peaks

The differences in the thermal conditions in the atmosphere near mountain peaks and the presence of forced ascents of air lead to the

more intensive convective development of clouds directly above the higher peaks, in particular above the Yalta Yayla Mountains, when thicker Cu are developed above the protruding mountain peaks. This type of pattern was observed in weak winds on the periphery of a low pressure region.

3. Altocumulus Cloudiness, Connected with the Passage of a Cold Front

Beginning on the evening of the 22 of August 1957 the sky was covered with long series of Ac undulat., recorded by a photographic panorama. At 0600 hours on the morning of 23 August the sky was covered with an unusual form of Ac floc. (Fig. 2), which by 0700 hours had been replaced by Ac virga of apparent crystalline structure. This cloudiness was connected with the passage of a cold front from the west.

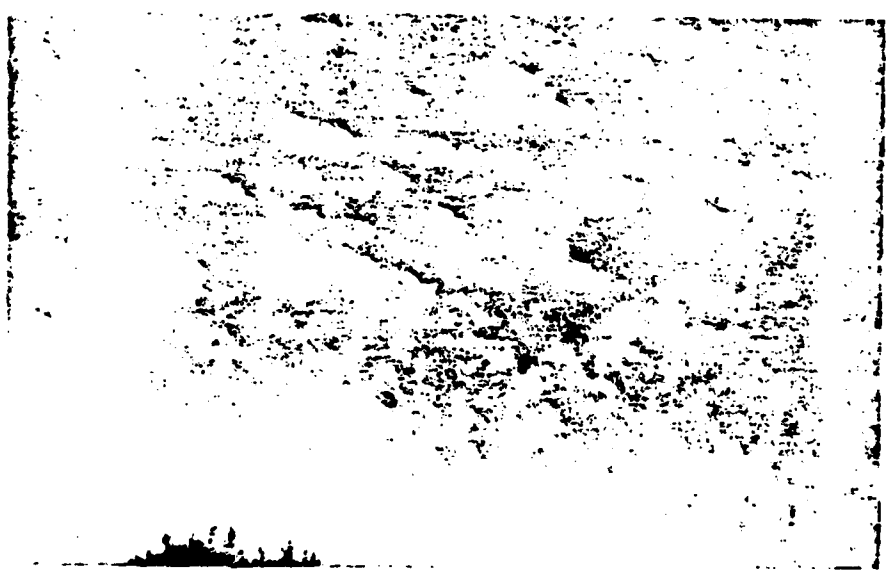

Fig. 2

4. The Giant Lenticularis of the Crimean Bora

After the passage of a cold front, on the morning of 24 August, with a strong wind from the direction of the sea, above the entire Yayla there hung a solid arc of bora cloud - of the lenticularis type. It

was limited from above by a uniform surface and a homogeneous microstructure of cloud elements of the lenticularis type. The cloud developed during the flowing over of the mountains of a comparatively thin layer of cold air directly under the inversion of a cold front.

There, where rather high mountains (in front of the Simeiz Yayla) are located closer to the sea, a whirling cloud arc was formed, on the forward surface of which cloud jets, directed upwards, appeared and disappeared.

A bora cloud was formed behind the cold front in the eastern part of the approaching anticyclone in strong northwest winds.

5. Two Cases of Sea Fog and St

a) On 27 June 1958 at 0700 hours in the morning an approaching sea fog-St arc was detected in the southeast above the sea (Fig. 3). On the left the fog arc streteched in the distance to the coast, and on the right it lost itself in the depth of the sea. Thick waves of this sea fog rushed past with interruptions above the coast until 1400-1500 hours in the afternoon (Fig. 4). Trees, buildings, mountains and the sun were drowned in the fog waves. The entire process was recorded on panoramic, and also on repetitive photographs.

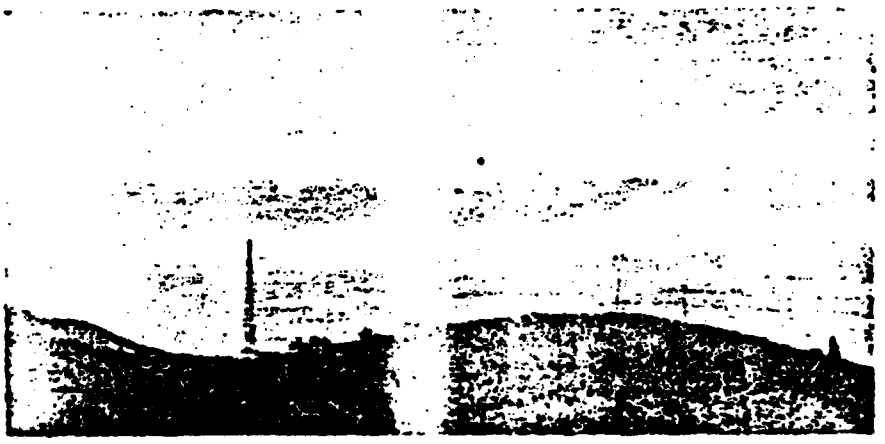

Fig. 3

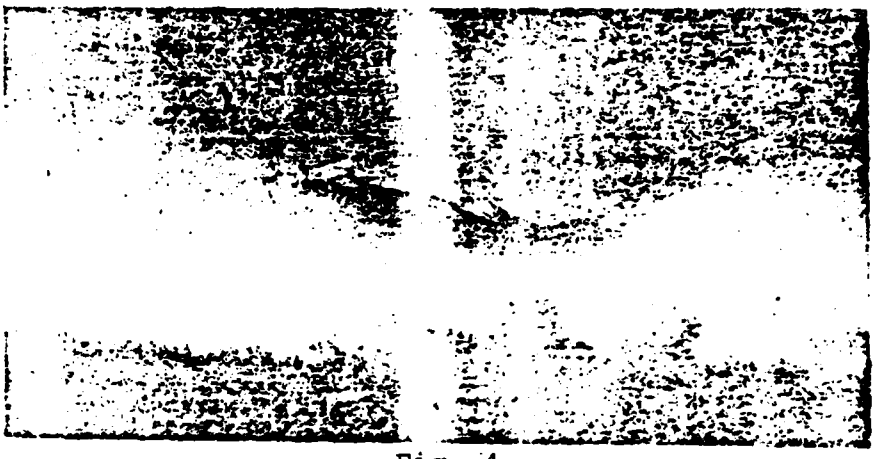

Fig. 4

On a synoptic map the fog was recorded on the southern and western coast of the Black Sea. Above the sea was located somewhat colder air, limited on the south by an old occlusion front, which, possibly, was also located near the southern coast of the Crimea.

b) On 4 July 1958 in the morning above the mountains were visible only Cu ans St, which were moving in the direction of the sea. However, at about 1130 hours in the morning, low over the sea there was detected an St cloud in the form of an individual, low, flat, light heap with a sharply outlined upper edge. It was moving approximately in a WNW-ESE direction. Later, over the sea from behind Cape Faros similar, but ever increasing in their dimensions cloud formations appeared and moved in the same direction. They especially increased in size in their horizontal dimensions (Fig. 5).

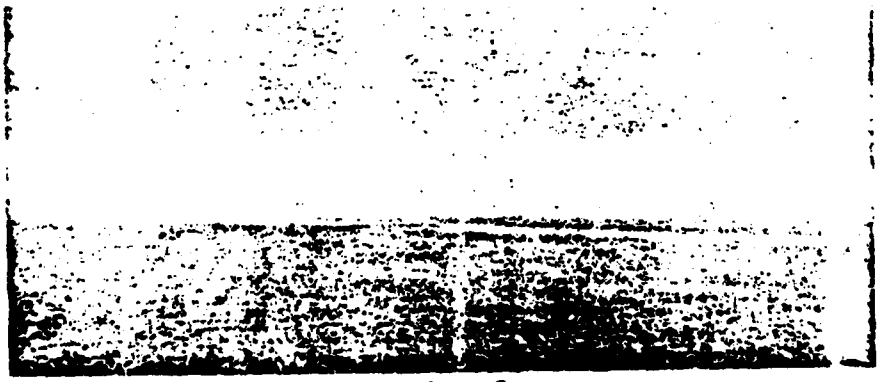

Fig. 5

According to the pilot balloon observations west winds with speeds of up to 15 m/s occurred at a height of 200-300 m above sea level. Northwest and north winds, but with speeds of only 5-10 m/s, were observed at a greater height. The Crimea was located under the effect of the northern periphery of a high-pressure nucleus.

6. A Cb System of a Cold Front, Located Over the Black Sea

On the evening of 29 June 1958 at 1700-1800 hours, "anvils" (ambos) of an entire Cb system, developing and stretching towards the north, moved in the east over the sea (Fig. 6). The movement of the Cb occurred approximately from south to north. A thunderstorm at Kerch' was recorded on a synoptic map at 2100 hours. A cold front was located along the Dnepropetrovsk-Kerch'-Novorossiysk line and east of the Black Sea. The front moved slowly towards the east. According to the pilot balloon data at 1830 hours at Katsiveli the wind at a height of 1 km was southerly in direction with speeds of 9-10 m/s, then it changed at a height of 2.5 km to a south-south-east wind with speeds of 14-16 m/s.

This increase in wind speed with height also led to an elongation of the Cb anvils, which was recorded by a series of repetitive photographs. In accordance with the map of relative baric topography of 500/1,000 mbar on the evening of 29 June in the region of the Crimea large contrasts in air temperature were indicated; cold air was located to the west of the cold front.

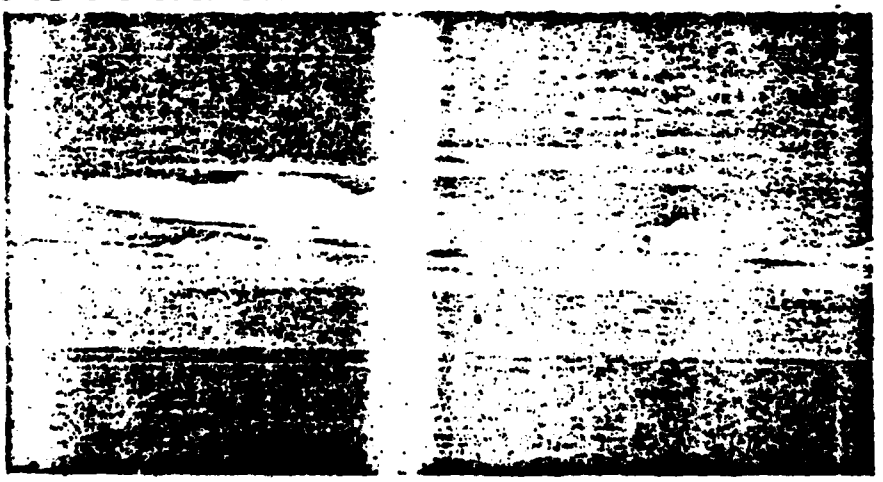

Fig. 6

7. Three Cases of Ac Lenticularis

a) On 28 June 1958 at about 1700 hours Ac lenticularis were observed over the mountains: The movement of the individual cloud elements was noticeably from the southwest. According to the pilot balloon observations at Katsiveli at 1820 hours, beginning at 1,600 m the wind from the northeast and the southwest changed to the southwest with a speed of from 6 to 10-12 m/s at a height of 3,000-4,000 m, where the clouds were located.

b) On 2 July 1958 Ac lenticularis were observed for a long time over the mountains on the northeast horizon beyond Ay-Petri. Their stratified structure was evident on the photographs. The direction of the major axes of the clouds was northwest-southeast (Fig. 7). At 1700 hours below the Ac, directly above the mountains, Cu were visible, moving towards the sea. According to the data of the pilot baloon at 1735 hours at a height of 1,000-1,500 m the wind was northwest with a speed of 9-11 m/s, and at 1235 hours at a height of 3,000 m it was west with a speed of 18 m/s. At 1500 hours in accordance with the map of baric topography the geostrophic wind was coming from the northwest, corresponding to the direction of orientation of the major axes of the lenses (lenticular clouds).

Fig. 7

c) At 0800 hours of the morning of 7 July 1958 an Ac lenticularis of very odd shape was observed almost at the zenith - one edge of the

cloud consisted of a great number of very fine jets, branching out from the cloud. At 0900 hours in the morning the observation site was located under the effect of the southwestern periphery of a cyclone. At 0930 hours in the morning at Katsiveli sharp changes took place in the wind with height: below it was west-south-west, at a height of 1,200 m it was north-east and at a height of 2,200 m it was a north-west wind.

8. Examples of Photogrammetric Investigations. Calculation Results for One of the Cumulus Clouds.

On 15 August 1957, FrCu clouds, eroded in proportion to their distance from the mountains, moved from the east, from the mountains. In accordance with the calculations of M. V. Kartashova, it was possible to construct a vertical profile and the approximate topography of one of these types of clouds (Fig. 8).

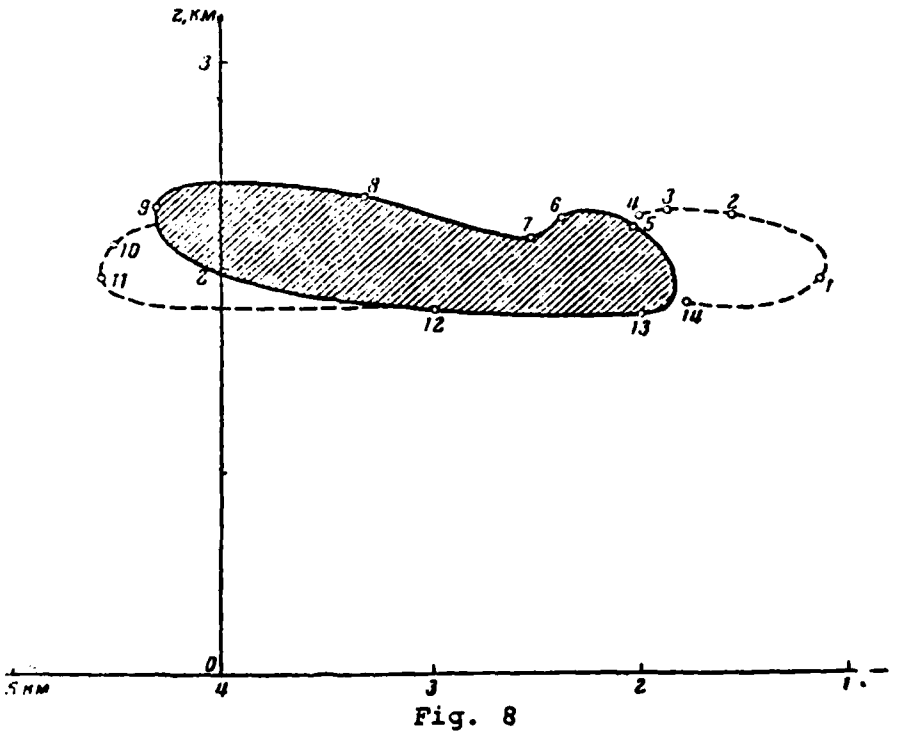

Fig. 8

The cloud stretched in a meridional direction. It length was about 2.5 km and its width 0.9-1.0 km (Fig. 12). The vertical thickness of

the cloud was from 400 yo 600 m. The lower base was at a level of 1,800 m. The front edge of the cloud moved during a 3 minute period to the west-south-west a total of 740 m, which gives an average speed of movement of the edge of the cloud (from east-north-east) od 4.1 m/s. Since melting of the cloud occurred, then it is clear, that the speeds of the wind at this height should be greater than that indicated; the area of the horizontal cross section of the cloud decreased.

From the pilot balloon data at Katsiveli the following wind directions (degree) and speeds (m/s) were observed:

Height	At 1530 hours	At 1830 hours
1,500 m	55°-6 m/s	18°-5 m/s
2,000 "	37°-5 "	63°-8 "
2,500 "	33°-9 "	74°-8 "

The base photographing was carried out at 1643.5 hours-1646.5 hours.

9. Calculation Results for an Ac lenticularis System.

On 31 July 1958 an Ac lenticularis type cloud system was located over the sea. The photogrammetric photographing of the sky with TAL photographic theodolites and the processing, carried out by N. N. Kondrat'yev with the aid of a stereocomparator of the MGU (Moscow State University) Aerial Photographic Methods Laboratory, of the photographs, obtained at 0808 hours and 0810 hours, gave the spatial coordinates for 20 points of the clouds.

The x axis was directed along the base from north-west to south-east, and the y axis - from south-west to north-east.

Let us present the data for five points of one of the clouds for both periods (0808 hours and 0810 hours). (Trans. note: See next page).

Thus, the Ac lenticularis clouds were located at a level of the order of 4,000 m and the individual points of the cloud were at a distance from the observation site at Katsiveli of more then 30 km[1].

1. From Katsiveli to Yalta on a straight line is about 31 km.

No.	y,m	x,m	z, m above sea level
4	13505/13226	3447/2916	4015/3931
5	15766/16283	2225/2227	4214/4287
6	22420/22124	320/607	4243/4198
7	19318/18334	2568/2635	3878/3835
8	16235/17162	6067/6539	3918/3947

The plotting on a topographic map of the data of all 20 points gave an accurate configuration of the clouds and their location relative to each other, and relative to the sea coast and the mountains (Fig. 9; the descent from the Yayla to the coast line is hatched). Mainle, the Ac lenticularis were located above the coast line and the sea in the form of three wave systems, the distance of which between them and the rocky cliff was approximately 8,000 m.

The waves were located parallel to the Yayla and perpendicular to the wind direction at the height of the clouds (about 4 km); there were no clouds above the Yayla.

At 0945 hours there was a north-west flow with speeds of 7-10 m/s over Katsiveli, above the mountains, to a height of 3,600 m. A strong north-west wind was observed on the baric topography map at 1500 hours, at a height of the order of 5,000 m. A cold front was located over the Black Sea, oriented from Novorossiysk to the south-west. The peaks of the cloud waves (the major axes of the Ac lenticularis) were perpendicular to the air flow.

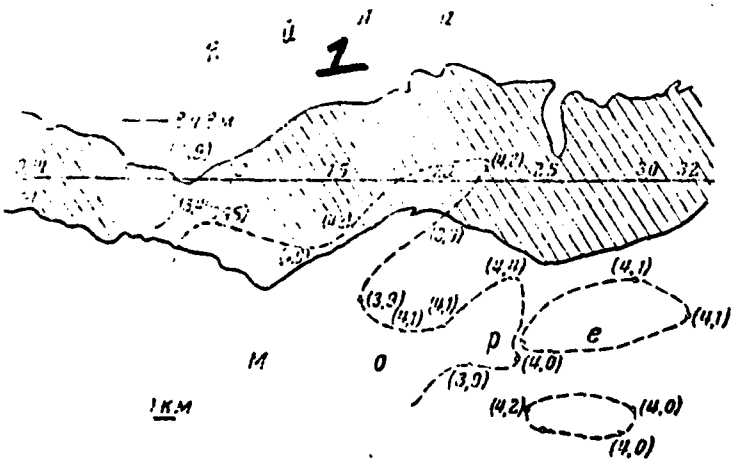

Fig. 9

KEY: 1 - Yayla.

On the morning of 19 July 1958 Cu in the form of narrow towers over the mountains (Yayla) moved and grew along the vertical (Fig. 10). From 0941 hours to 0946 hours 6 photographs of these clouds with intervals of 1 min were made. The photographing was carried out from one point and in this case only by hand. Knowing the angles, at which the mountain peaks were visible, which appeared on the photographs, it was possible to determine, in which direction (azimuth and height above the horizon) the photographs were made. Assuming the height of the lower base of the Cu towers to be approximately equal to 2 km, calculations were carried out for the clouds: a) at 0945 hours and b) at 1044 hours, 1047 hours and at 1049 hours.

The growth and the speed of motion of the peaks of the developing Cu were traced during these periods. The development of the clouds was reminiscent of the ejection of solar prominences.

At 0941 hours the Cu were located above the mountains at a distance of 8-9 km from the observation site in a north-west direction. The movement during a 4 minute period along the horizontal was about 1.2 km, which gives a speed of 5 m/s. The height of the Cu peak was 3,600 m. The vertical speed of growth of the cloud was 2.52 m/s, the movement was from the north-north-east to the south-south-west.

At 1044-1049 hours the Cu were at a distance of 15-16 km to the north-west of the observation points. Their movement was from the north-north-west at a speed of 4.7 m/s; the peak of the cloud was as high as 6,100 m, the vertical speed was 2.62 m/s. From the pilot balloon observations at Katsiveli at 0930 hours the wind below was west-south-west, and above the mountains it was north-north-east with a speed of up to 5 m/s.

According to the synoptic map for 0900 hours in the morning to the east of the observation site the small cyclone was located (weakly expressed), developed at almost a meridional front with the wave peak at the center of the cyclone. The developed Cu in the form of towers, their movement and variations in movement are connected with the mentioned cyclone and its movement. After 1235 hours in the afternoon

there were rains and downpours.

11. Exceptional Shapes of Orographic Clouds in the Evening

These clouds were photographed in 3 July 1958 with roll-film (24x x36 mm) cameras, with a 135-mm telephoto lens by hand and with a 50-mm objective lens with the base on a tripod, and also with a movie camera.

The FIRST PERIOD of photographing was from 1759 hours to 1804.5 hours.

The SECOND PERIOD was from 1809 hours to 1813 hours.

The THIRD PERIOD was from 1842 hours to 1848 hours.

In the FIRST PERIOD a cloud "jet" resembling a boomerang (1759 hours) was detected in the direction of Yalta from Katsiveli, the front part of the "jet" was lifted upwards. On the basis of the theodolite photograph it was evident on the horizontal and the vertical projections of the cloud, that the forward par of the cloud was at a distance of 18.6 km from the observation site, and the rear part was at a distance of 23 km. The lower base of the "jet" was at a height of 4.0 km, the diameter of the "jet" was 600-800 m, and the peak was located at a height of 6.4 km. Fig. 11 shows a profile of the cloud from the calculations of V. S. Kiseleva and T. N. Bibikova.

The "jet" rapidly changed its shape. Within 1.5 min its upper part had already moved 800 m in the direction of the sea, after 0.5 min it had moved another 400 m and after another 1.0 min it had moved 250 m more. Thus the movement of the cloud peak to the sea was 1,450 m in 3 min. The average speed of propagation of the cloud peak towards the sea was 7.8 m/s, however, this does not indicate, that these were the horizontal wind speeds. The new formation of a cloud in the upper part of the "jet" played a considerable role in this movement, apparently due to the condensation processes in the developing vertical movements (Fig. 12-15).

Towards the end of the process the shape of the "jet" was retained only in its lower part. This process was photographed with a movie camera.

The *SECOND PERIOD* pertains to 1809 hours. Unfortunately, this process was not recorded by base-line photogrammetric photographing. At 1809 hours there was visible from Katsiveli in the northeast (projecting above the northern part of Koshka Mountain) a cumulus cloud with rather fractured edges, which in the upper part of its peak changed to a column, inclined at an angle of 45-50° to the horizon (in the direction of the mountains), in which counterclockwise twisting was evident. It is tentatively possible to estimate the height of the lower base of the Cu at 2 km, and the horizontal elongation - of the order of 4 km. The narrow part of the vortex tube was approximately 1 km in diameter. The vortex with its vertex, apparently, exceeded 6 km.

At 1812 hours the vortex began to turn pale and at 1813 hours only the disintegrating jets jets remained, separated from the remaining Cu (Fig. 16 and 17).

In the THIRD PERIOD a small cloud, of obviously orographic origin, appeared high above the horizon. The photographs, taken with a telephoto lens at 1842, 1845, 1847, 1847.5 and at 1848 hours differed considerably from each other. In the cloud movements with a horizontal axis were evident, with descending movements from the direction of the sea and obvious ascending jets from the direction of the mountains with very homogeneous condensation (as in Ac lenticularis).

The pilot balloon observations at Katsiveli at 1745 hours at a height of up to 2,000 m manifested northwest winds with speeds of from 10 to 5 m/s. The Crimean Peninsula in the second half of the day of 3 July was under the effect of the front part of a low-pressure trough, stretching from east to west. An eroded cold front was in this trough, passing through Kherson. The enumerated features of cloud development, apparently, were connected with purely short-term, local, but very intensive processes.

In conclusion we would like to mention one case of a thunderstorm, which we observed in the Ay-Petri Mountains. On 5 July at 1520 hours an approaching thunderstorm Cb arcus cloud was visible in the north-west. It had a very large extent in the horizontal direction and a very dark base, which encompassed the horizon for approximately 120°. At 1550 hours the cloud had moved considerably to the east and had approached so close. that its vertex was no longer included in a panoramic photograph made with a camera. Arcus arcs (of the vast lenticularis type) were distinctly evident.

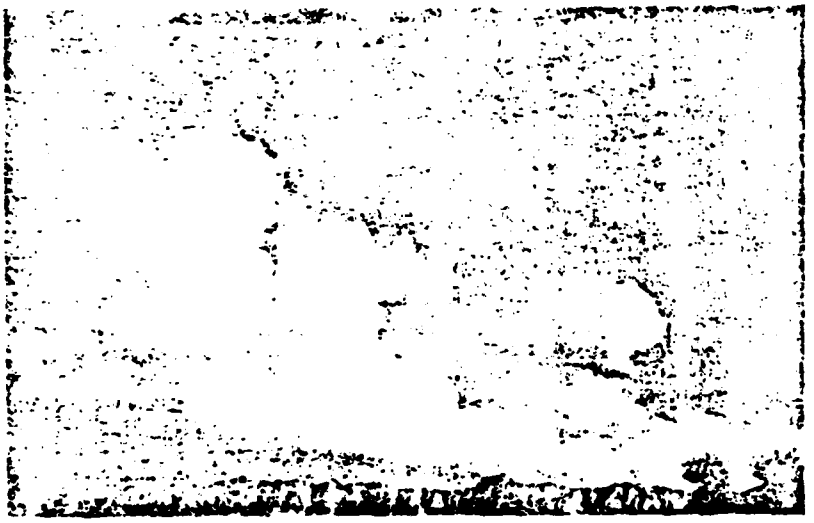

Fig. 10

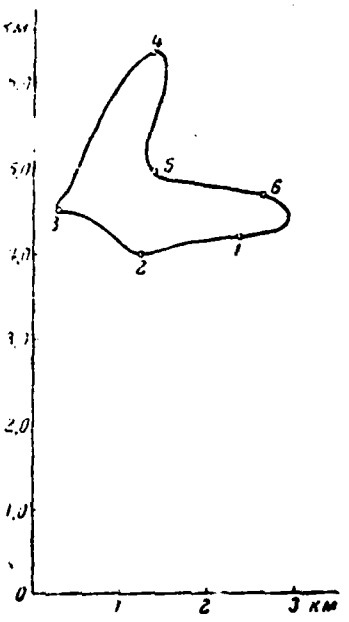

Fig. 11

At 1604 hours, under the front part of the arcus moving from the north-west, tongues of St, formed over Yalta, were visible, appearing on the upland. These St appeared from Yalta Bay along a gorge (trough) between the mountains to the east of Yalta. Their formation had taken place after an electrical rain storm had passed. Later, in the descent to Yalta we saw the individual clouds of this same level (below the mountain peaks), which were moving slowly towards the mountains. The clouds arose in a daytime breeze flow and went almost counter to the movement of the Cb over the mountains.

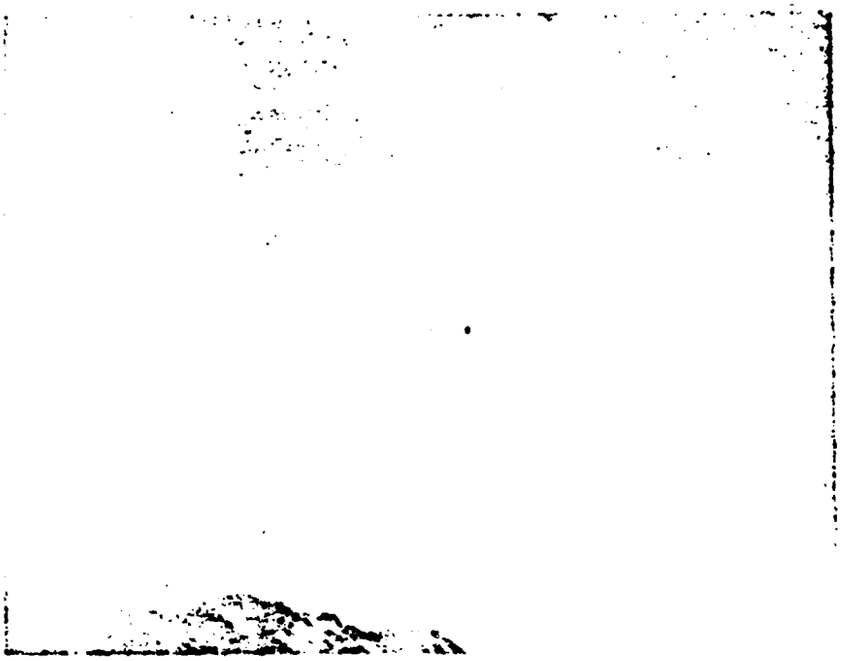

Fig. 12

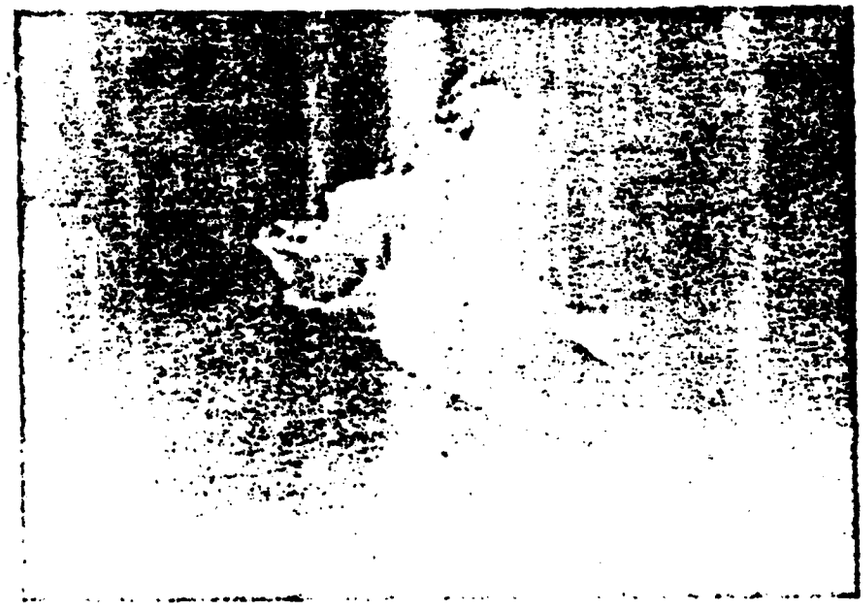

Fig. 13

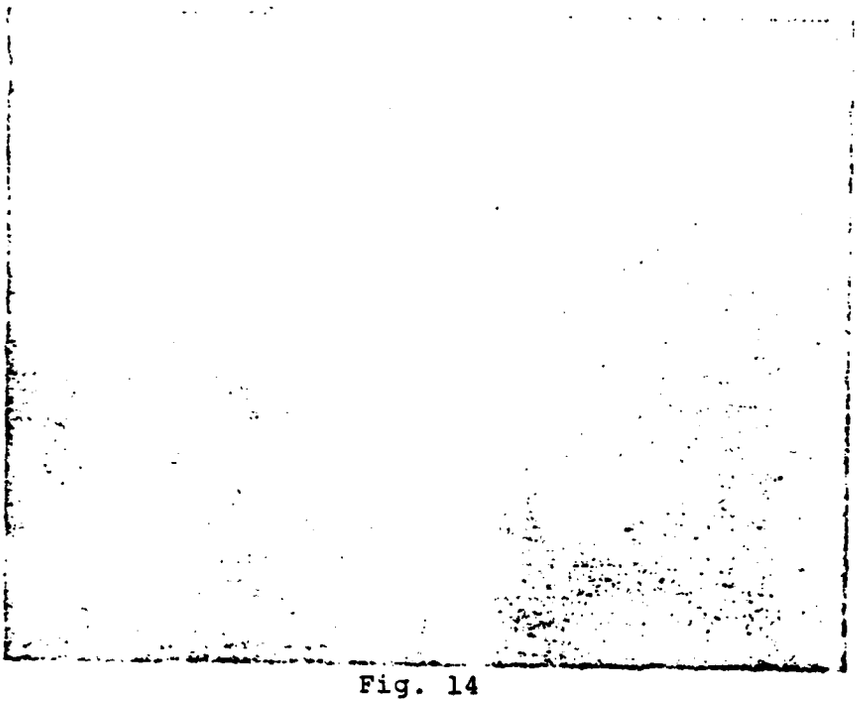

Fig. 14

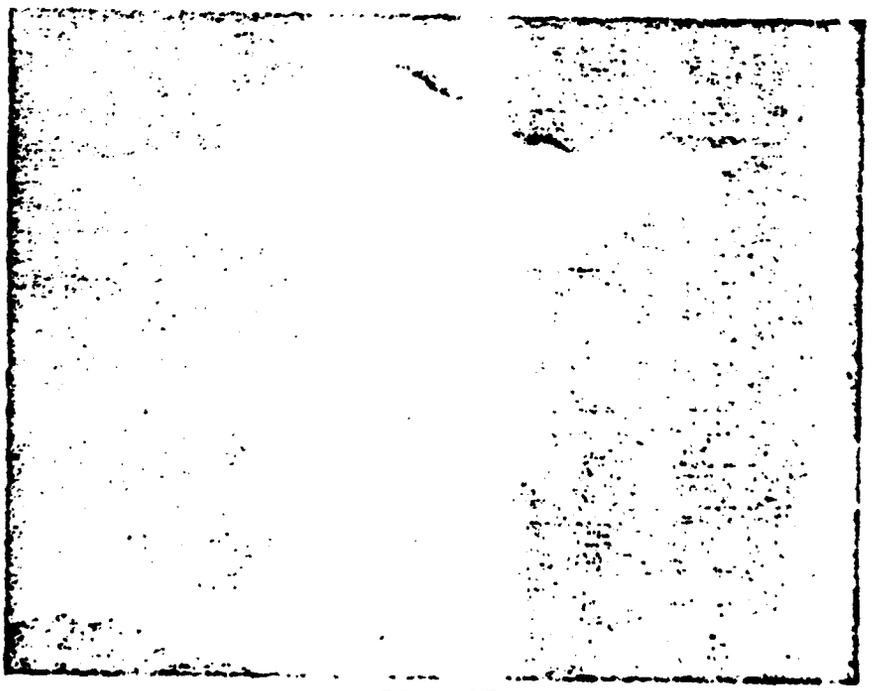

Fig. 15

Fig. 16

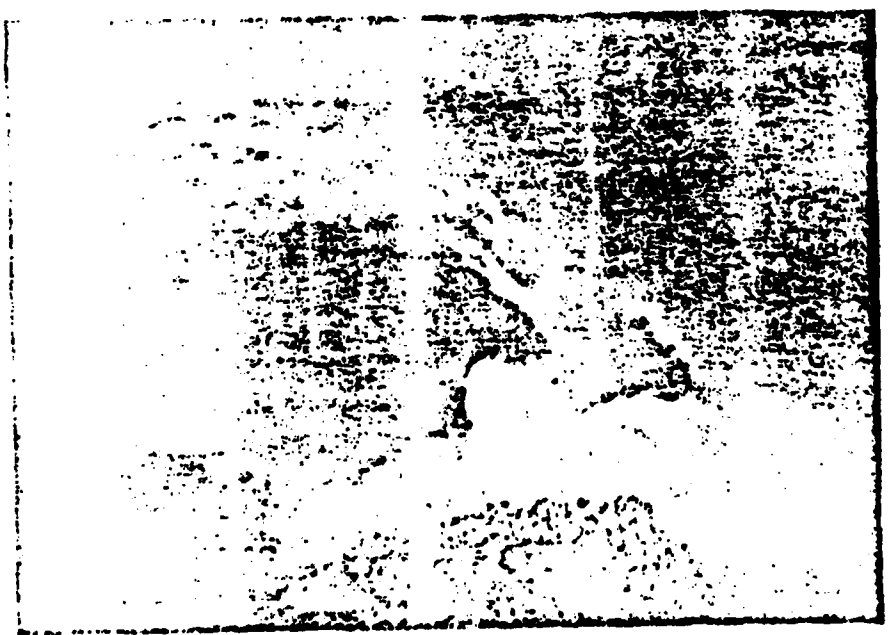

Fig. 17

The experience of the work in the expeditions of 1957 and 1958 confirmed the possibility of obtaining valuable material (especially by the motion-picutre photography method), very important for the study of the process of cloud development.

Subsequently, repeat expeditions are being planned to study the clouds of the Crimean coast; in particular deficiencies, detected in the past expeditions, will be taken into account.

An experiment will be conducted involving the motion-picture filming clouds from onboard the ship "Moskovskiy Universitet," which will make it possible to obtain a "space-time" panorama of the location of clouds over the coast.

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